

INDOOR AIR QUALITY REASSESSMENT

**James Clark Elementary School
65 Oxford Street
Agawam, Massachusetts**



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
November 2003

Background/Introduction

At the request of Judy Dean, Western Massachusetts American Lung Association, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the James Clark Elementary School (JCES), 65 Oxford Street, Agawam, Massachusetts.

On January 10, 2003, an initial visit to conduct an indoor air quality assessment was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA. Mr. Feeney was accompanied by Ms. Dean. During the initial visit, building staff expressed concerns about the pooling of water on grounds outside the rear of the building, during spring and summer months. Water pooling reportedly resulted in water penetration into the building. These conditions could not be evaluated during the initial visit due to winter weather and extensive snow cover. Therefore, Mr. Feeney agreed to return to the building as during the program's spring/summer schedules. On July 31, 2003, Mr. Feeney returned to the JCES to conduct an assessment of the building exterior.

The JCES is a one-story brick building constructed in 1957. Additions were made in 1998 and 2001. From an aerial photograph, it appears that the JCES consists of seven distinct wings (Picture 1). The school contains general classrooms, library, offices, gym, cafeteria and kitchen. Windows in the JCES are openable. The 2001 addition included a wing that houses the Collaborative Program for Children with Autism (COPA). COPA is not part of the Agawam Public School system and is not included in this indoor air quality assessment.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The JCES houses a kindergarten through fourth grade student population of approximately 400 and has a staff of approximately 40. Tests were taken during normal operations at the school and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were slightly above 800 parts per million (ppm) parts of air in fifteen of twenty-five occupied areas examined, indicating a possible ventilation problem in the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit ([Figure 1](#)). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Univents were operating in classrooms throughout the school at the time of the assessment. Although exterior univent fresh air intakes were free of blockages from snowdrifts, obstructions to interior portions of the univent were seen. Items, such as papers and books were stored on top of univent air diffusers. In one classroom, a student's boots were placed in front of the univent return. In order for univents to

provide fresh air as designed, units must be allowed to operate while rooms are occupied and air diffusers and return vents must remain free of obstructions.

Exhaust ventilation is provided by a ducted system, where air is drawn into ceiling-mounted exhaust grills. Of note was the presence of another vent within the closet of classrooms in the 1957 portion of the school. This type of vent would draw air through a space beneath the closet door. It appears that these vents were abandoned when the building was renovated. While ceiling mounted exhaust vents were drawing air, the closet vents were not, and some appeared to be back-drafting cold air. The source of cold air is most likely from spaces above the ceiling, since it appears that the original exhaust vents were removed from the roof. Sealing of these vents will prevent the migration of particles and other materials that can be present in the abandoned ducts or ceiling space.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The last balancing of these systems was presumed to be after installation in 1998. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in

the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please consult [Appendix I](#).

Temperature measurements ranged from 71° F to 74° F, which were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. Staff expressed temperature complaints, primarily related to heat issues in the library. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 19 to 33 percent, which were below the BEHA recommended comfort range in all areas surveyed. The BEHA recommends that indoor

air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

During the initial assessment, a significant musty odor was detected in the school hallway adjacent to the COPA hallway. The COPA is an air-conditioned facility that operates during the summer. The COPA is connected to the JCES via a carpeted hallway. The carpeted COPA hallway also branches to an exterior door. Reports from school staff indicated that during the spring and summer of 2002, JCES hallways and classrooms in close proximity to the COPA hallway became moistened. At various times in May, July and August of 2002, New England experienced a stretch of excessively humid weather. For example, from July 4, 2002 through July 12, 2002, weather conditions produced an outdoor relative humidity that, at various times, ranged from 73 to 100 percent without precipitation (The Weather Underground, 2002). Outdoor relative humidity conditions coupled with anecdotal reports indicate that a condensation problem may exist.

Condensation is the collection of moisture on a surface that has a temperature below the dew point. The dew point is a temperature that is determined by air temperature and relative humidity. As an example, at a temperature of 80° F and relative humidity of 80 percent, the dew point for water to collect on a surface is approximately 76° F (IICRC, 1999). If the air conditioning system is set to maintain a temperature below the dew point, condensation can accumulate on building components and other materials. Therefore, any surface that has a temperature below 76° F would be prone to condensation. Use of the COPA exterior door tends to introduce hot moist air into the carpeted hallway. Once water accumulates, this condition can

result in chronic moistening of hallway carpet. Chronic moistening of carpeting can produce fungal growth. The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24-48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Once mold growth has occurred, disinfection of some materials may be possible. Since carpeting is a porous surface, disinfection is likely to be ineffective.

Building staff provided a theory that the high water table around the building was a contributing source of moisture in the building. As discussed, Mr. Feeney returned in mid summer to examine the school grounds. The grounds surrounding the new wing and COPA were free of standing water (Pictures 2 and 3). Conditions within the hallway and classrooms with reported moisture accumulation were also observed. In the experience of BEHA staff, moisture migrating through slab would degrade adhesive in contact with the cement producing loose floor tiles. In addition, cracks and/or uneven floor surfaces due to cement degradation would also be present. No loose floor tiles, cracks or uneven floor surfaces were found in hallways or classrooms, indicating that groundwater penetration through the slab was unlikely as a source of moisture in this area.

Shrubbery and other plants exist in close proximity to foundation walls (Picture 4). The growth of roots against exterior walls can bring moisture in contact with wall brick and eventually lead to cracks and/or fissures in the below ground slab. Over time, this process can undermine the integrity of the building envelope and provide a means of water entry into the building via capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Several classrooms contained a number of plants. Plant soil and drip pans can serve as sources of mold growth. Plants should be located away from univents and exhaust ventilation to prevent aerosolization of dirt, pollen or mold. Two aquariums were also observed in the building. Aquariums should be properly cleaned and maintained to prevent bacterial/mold growth and nuisance odors.

Other Concerns

A number of other conditions that can affect indoor air quality were identified. One classroom contained a product known as “Artificial Snow”, which simulates frost on windows. This spray product contains the flammable materials heptane and xylene (CPC, 1998). Heptane and xylene are volatile organic compounds (VOCs) that are associated with irritation to the eyes, nose and throat.

Classrooms contained a number of conditions that may attract rodents. Stored food containers were seen in some classrooms. In addition, one classroom had student art projects that were made with food. Under current Massachusetts law (effective November 1, 2001) the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation. Steps to reduce/eliminate pathways/food sources that can attract pests should be taken.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs. Tennis balls are made of a number of materials that are a source of respiratory irritants. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Constant wearing of tennis balls can produce fibers and cause materials to off-gas TVOCs. Use of tennis balls in this manner may introduce latex dust

into the school environment. Some individuals (e.g. spina bifida patients) are highly allergic to latex (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as [Appendix II](#) (NIOSH, 1998).

Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs (e.g. methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat. Cleaning products were found in a number of classrooms. Cleaning products contain chemicals that can be irritating to the eyes, nose and throat and should be kept out of reach of students.

Finally, of note was the amount of materials stored inside classrooms. In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g. papers, folders and boxes) make it difficult for custodial staff to clean. Dust can be irritating to the eyes, nose and respiratory tract. In addition, a number of exhaust vents in classrooms were noted with accumulated dust. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made:

1. Determine the function of the vents in the ceiling of closets in the 1957 portion of the building. If disconnected from the general exhaust ventilation system, seal each vent.

2. Consider removing the carpeting prone to moisture (e.g. COPA hallway), and replacing with an alternative sound attenuating floor tile.
3. Render the hallway door that separates the COPA wing from the remainder of the building as air tight as feasible to prevent cool air penetration into non-air conditioned sections of the school. This can be accomplished by installing door sweeps and weather-stripping in the hallway doors.
4. Render the exterior COPA hallway door airtight, in a manner consistent to methods described in Recommendation # 3.
5. Use dehumidifiers during hot, humid weather to reduce relative humidity in areas that are not air-conditioned and in close proximity to the COPA wing. If dehumidifiers are employed, ensure that water collection containers are emptied to prevent spillage. Maintain dehumidifiers as recommended by the manufacturers to prevent microbial/bacterial growth. Use dehumidifiers on an “as needed” basis during extended periods of hot, humid weather (outdoor relative humidity greater than 70 %, for a period longer than 24 hours).
6. Ensure univents and exhaust vents are free of obstructions.
7. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
8. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.

9. Operate both supply and exhaust ventilation continuously during periods of school occupancy, independent of classroom thermostat control.
10. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
11. Move plants away from univents in classrooms. Ensure all plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Consider reducing the number of plants.
12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
13. Use the principles of integrated pest management (IPM) to rid the building of pest. A copy of the IPM recommendations can be obtained from the Massachusetts Department of Food and Agriculture (MDFA) website at the following website:
http://www.state.ma.us/dfa/pesticides/publications/IPM_kit_for_bldg_mgrs.pdf. Activities that can be used to eliminate pest infestation may include the following activities.
 - a) Avoid using food as components in student artwork.
 - b) Rinse out recycled food containers. Seal recycled containers in a tight fitting lid to prevent rodent access.

- c) Remove non-food items that rodents are consuming.
 - d) Stored foods in tight fitting containers.
 - e) Avoid eating at workstations. In areas where food is consumed, periodic vacuuming to remove crumbs are recommended.
 - f) Clean crumbs and other food residues from ovens, toasters, toaster ovens, microwave ovens coffee pots and other food preparation equipment on a regular basis;
 - g) Examine each room and the exterior walls of the building for means of rodent egress and seal. Holes as small as ¼” are enough space for rodents to enter an area. If doors do not seal at the bottom, install a weather strip as a barrier to rodents. Reduce harborages (cardboard boxes) where rodents may reside (MDFA, 1996).
14. Discontinue the use of tennis balls on chairs to prevent latex dust generation.
 15. Store cleaning products properly and out of reach of students. Consider discontinuing use of artificial snow in classrooms.
 16. Consideration adopting the US EPA document, “Tools for Schools”, as a means to maintain a good indoor air quality environment in the building (US EPA, 2000). This document can be downloaded from the Internet at <http://www.epa.gov/iaq/schools/index.html>.
 17. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH’s website at <http://www.state.ma.us/dph/beha/iaq/iaqhome.htm>.

References

- ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.
- BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials and Code Administrators International, Inc., Country Club Hill, IL
- CPC. 1998. Material Safety Data Sheets for Santa Snow Frost. Chase Products Company, Maywood, IL.
- IICRC. 1999. IICRC S500 Standard and Reference Guide for Professional Water Damage Restoration. 2nd ed. The Institute of Inspection, Cleaning and Restoration Certification, Vancouver, WA.
- Lstiburek, J. & Brennan, T. 2001. Read This Before You Design, Build or Renovate. Building Science Corporation, Westford, MA. U.S. Department of Housing and Urban Development, Region I, Boston, MA
- Mass. Act. 2000. An Act Protecting Children and families from Harmful Pesticides. 2000 Mass Acts c. 85 sec. 6E.
- MDFA. 1996. Integrated Pest Management Kit for Building Managers. Massachusetts Department of Food and Agriculture, Pesticide Bureau, Boston, MA.
- NIOSH. 1997. NIOSH Alert Preventing Allergic Reactions to Natural Rubber latex in the Workplace. National Institute for Occupational Safety and Health, Atlanta, GA.
- NIOSH. 1998. Latex Allergy A Prevention. National Institute for Occupational Safety and Health, Atlanta, GA.
- OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.
- Sanford. 1999. Material Safety Data Sheet (MSDS No: 198-17). Expo® Dry Erase Markers Bullet, Chisel, and Ultra Fine Tip. Sanford Corporation. Bellwood, IL.
- SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC. http://www.sbaa.org/html/sbaa_mlatex.html
- SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0
- SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

US EPA. 1992. Indoor Biological Pollutants. US Environmental Protection Agency, Environmental Criteria and Assessment Office, Office of Health and Environmental Assessment, Research Triangle Park, NC. ECAO-R-0315. January 1992.

US EPA. 2000. Tools for Schools. Office of Air and Radiation, Office of Radiation and Indoor Air, Indoor Environments Division (6609J). EPA 402-K-95-001, Second Edition.
<http://www.epa.gov/iaq/schools/tools4s2.html>

Weather Underground, The. 2002. Weather History for Westfield, Massachusetts, July 4, 2002 through July 12, 2002.

<http://www.wunderground.com/history/airport/KBAF/2002/7/4/DailyHistory.html>

<http://www.wunderground.com/history/airport/KBAF/2002/7/5/DailyHistory.html>

<http://www.wunderground.com/history/airport/KBAF/2002/7/6/DailyHistory.html>

<http://www.wunderground.com/history/airport/KBAF/2002/7/7/DailyHistory.html>

<http://www.wunderground.com/history/airport/KBAF/2002/7/8/DailyHistory.html>

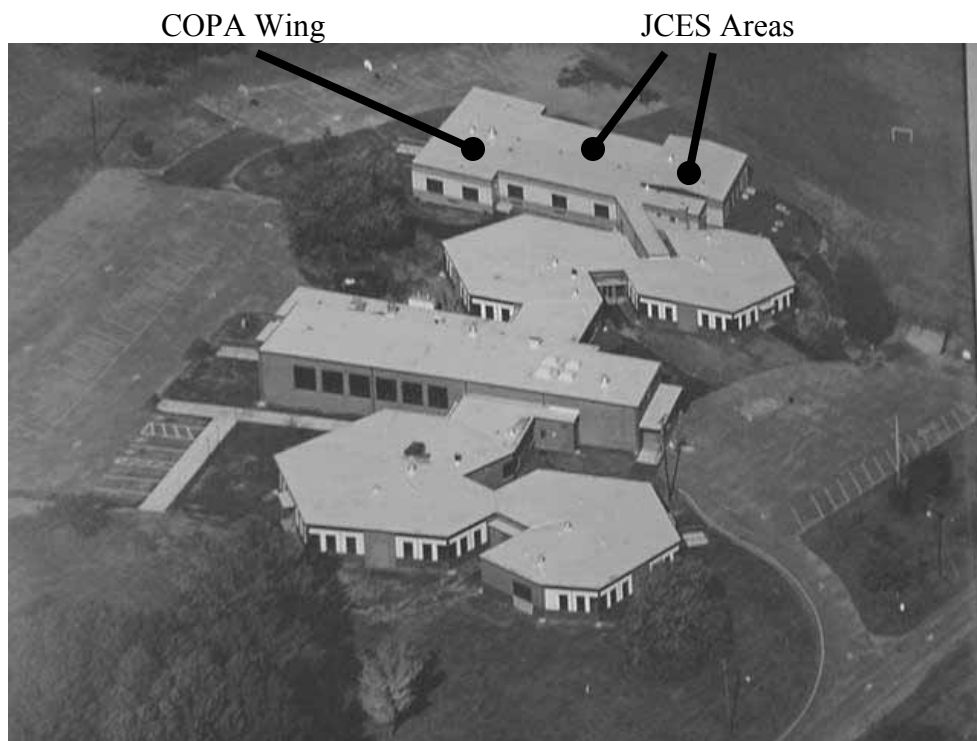
<http://www.wunderground.com/history/airport/KBAF/2002/7/9/DailyHistory.html>

<http://www.wunderground.com/history/airport/KBAF/2002/7/10/DailyHistory.html>

<http://www.wunderground.com/history/airport/KBAF/2002/7/11/DailyHistory.html>

<http://www.wunderground.com/history/airport/KBAF/2002/7/12/DailyHistory.html>

Picture 1



Aerial View of JCES (All Non-Highlighted Wings Contain JCES Facilities)

Picture 2



Rear Parking Lot near COPA Wing (Taken July 31, 2003, 2:19 PM)

Picture 3



Another View Of Rear Parking Lot, near COPA Wing (Taken July 31, 2003, 2:22 PM)

Picture 4



Shrubbery near Exterior Wall of Building

TABLE 1
Indoor Air Test Results – James Clark Elementary School, Agawam, MA

January 10, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	247	35	29	N/A	N/A	N/A	N/A	
Room 5	816	72	25	17	Y	Y	Y	Tennis balls
Room 6	905	73	26	17	Y	Y	Y off	Musty Odor, food container, artificial snow spray can, clutter, DO
Room 7	822	73	25	17	Y	Y	Y	DO
Room 8	766	74	21	28	Y	Y	Y	Tennis balls, WB, DO
Room 4	828	73	26	22	Y	Y	Y	Mice/wastes, WB, DO
Room 3	832	73	25	19	Y	Y	Y	Mice, DO
Room 2	883	73	24	20	Y	Y	Y	Cold air – draft from exterior door, Tennis balls
Room 1	936	73	25	19	Y	Y	Y	
Gymnasium	1387	72	33	6	Y	Y	Y	DO

* ppm = parts per million parts of air

DO = Door Open

WB = White Board in Room

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

TABLE 1
Indoor Air Test Results – James Clark Elementary School, Agawam, MA

January 10, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Cafeteria	784	74	28	50+	Y	Y	Y	
Room 9	699	73	22	2	Y	Y	Y	Tennis balls
Room 10	1295	73	28	22	Y	Y	Y (1/2 backdraft)	Tennis Balls
Room 11								
Room 12	1093	74	24	20	Y	Y	Y	Books at vent
Room 13	945	73	25	20	Y	Y	Y	DO
Room 14	874	75	23	21	Y	Y	Y	Tennis balls, DO
Room 15	1008	75	24	18	Y	Y	Y	DO
Room 16	1388	74	25	22	Y	Y	Y	
Media Center	368	74	19	0	Y	Y	Y	

* ppm = parts per million parts of air

DO = Door Open

WB = White Board in Room

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%

TABLE 1
Indoor Air Test Results – James Clark Elementary School, Agawam, MA

January 10, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Room 21	501	73	20	7	Y	Y	Y	DO
Faculty Room	733	72	22	8	Y	Y	Y	
Room 20	553	71	23	0	Y	Y	Y	DO
Room 17	718	71	24	19	Y	Y	Y	
Room 19	903	72	27	32	Y	Y	Y	Bowed CT
Room 18	614	71	25	0	Y	Y	Y	Plants, WB, DO
Room 24	665	72	25	0	Y	Y	Y	Stained carpet from photocopier
Main Office	729	71	25	1	Y	Y	Y	

* ppm = parts per million parts of air

DO = Door Open

WB = White Board in Room

Comfort Guidelines

Carbon Dioxide - < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature - 70 - 78 °F

Relative Humidity - 40 - 60%